

Polycentric systems for coping with collective action and global environmental change

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ABSTRACT

The 20th anniversary issue of *Global Environmental Change* provides an important opportunity to address the core questions involved in addressing “global environmental” problems—especially those related to climate change. Climate change is a global collective-action problem since all of us face the likelihood of extremely adverse outcomes that could be reduced if many participants take expensive actions. Conventional collective-action theory predicts that these problems will not be solved unless an external authority determines appropriate actions to be taken, monitors behavior, and imposes sanctions. Debating about global efforts to solve climate-change problems, however, has yet not led to an effective global treaty. Fortunately, many activities can be undertaken by multiple units at diverse scales that cumulatively make a difference. I argue that instead of focusing only on global efforts (which are indeed a necessary part of the long-term solution), it is better to encourage polycentric efforts to reduce the risks associated with the emission of greenhouse gases. Polycentric approaches facilitate achieving benefits at multiple scales as well as experimentation and learning from experience with diverse policies.

1. Introduction

Many problems conceptualized as “global problems” are the cumulative result of actions taken by individuals, families, small groups, private firms, and local, regional, and national governments. A pressing global problem faced in the contemporary world is reducing the emission of greenhouse gases (GHGs) by individuals and organizations around the world that cumulate to increase the threat of major climate change. Solving this problem requires collective action. To avert this global threat, many actors at diverse levels need to make costly decisions to reduce GHG emissions. Everyone benefits from reduced emissions even if they do not contribute any effort themselves (Cole, 2008; Sandler, 2004). As analyzed by distinguished policy analysts, reducing the threat requires an enforceable global treaty (Carraro, 2003; Nordhaus, 1994; Wiener, 2007).

Major debates exist in the policy literature related to climate change over key issues that need to be resolved to achieve efficient and fair mechanisms at a global level. One relates to the responsibility of developed countries for the current and immediate future levels of CO₂ in the atmosphere (Botsen et al.,

2008; Dellink et al., 2009). This is related to who should bear the primary burden of paying for solutions and the resistance of developing countries to participate at the same level as those who created the threat in the first place (Najam et al., 2003; Posner and Sunstein, 2008). Other debates relate to whether various “remedies” proposed to reduce carbon sequestration contribute or do not contribute to helping solve other environmental concerns. One puzzle is whether deforestation contributes to climate change primarily through releases of CO₂ to the atmosphere or whether changes in land cover, evapotranspiration, and cloud cover are as important and must be taken into account when planning afforestation efforts (Bala et al., 2007).

These are difficult questions. An enforceable agreement among the major emitters of GHGs will take a long time to develop. Given the lack of an enforceable international agreement to reduce GHG emissions, just waiting and doing nothing can defeat the possibilities of substantial remedy in time to prevent a major disaster.

In addition to the problem of waiting too long, “global solutions” negotiated at a global level, if not backed up by a variety of efforts at national, regional, and local levels, are not guaranteed to work well. While the level of CO₂ and other GHGs in the atmosphere may be relatively uniformly distributed at a megascale, the impacts of climate change differentially affect localities and regions by their geographic location, ecological and economic conditions, prior preparation for extreme events, and past investments.

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Further, while many of the effects of climate change are global, the causes of climate change are the actions taken by actors at smaller scales. The familiar slogan "Think Globally but Act Locally" hits right at the dilemma facing all inhabitants of the world. To solve climate change in the long run, the day-to-day activities of individuals, families, firms, communities, and governments at multiple levels must change substantially. Many who need to change their behavior, however, have not yet accepted their need to act in a different manner. They are waiting for an agreement at a global level before taking action. As discussed below, this is slowly changing, however, as more actors are learning about ways to reduce their own costs over time while taking actions that reduce the emission of GHGs.

The conventional theory of collective action predicts, however, that no one will voluntarily change behavior to reduce energy use and GHG emissions; an external authority is required to impose enforceable rules that change the incentives for those involved (Brennan, 2009). Analysts call for new global-level institutions to change incentives related to the use of energy and the release of GHGs (see Miller, 2004; Stavins, 1997). Given the presumption that collective-action problems that have global effects must primarily be "solved" by legal actions of a global authority, several questions need to be addressed as analysts undertake the next round of research on climate change. They include:

1. Is the conventional theory of collective action the best theory for analyzing how to reduce the threats of massive climate change, and, if not, what changes need to be made?
2. Are only global benefits generated from efforts to reduce GHG emissions, or are further benefits produced at multiple scales?
3. Would a polycentric approach be an improvement to the analysis of climate policy over exclusive reliance on proposing global solutions?
4. Are actions already being taken at less than global scale to reduce GHG emissions and can these cumulate to reduce the threat of major climate change?
5. When multiple governments and other organizations are involved in reducing GHG emissions, does that generate major leakages, inconsistent policies, inadequate certification, gaming the system, and free riding?

I will address each of these questions in the following sections of this article.

2. The conventional theory of collective action

The term "collective action" refers to settings where decisions about costly actions are made independently but outcomes jointly affect everyone involved. If independent decision makers seek only short-term material benefits, they do not achieve feasible outcomes that yield higher returns for *all* who are involved regardless of whether they make costly contributions. Participants posited as maximizing short-term material benefits and making independent choices are not predicted to achieve this outcome (Lichbach, 1996; Schelling, 1978; Vatn, 2005). Without *externally imposed* regulations at the global scale, the conventional theory predicts that no one will reduce emissions (Brennan, 2009).

The applicability of the conventional theory is considered to be so obvious by many scholars that few questions have been raised regarding whether this is the best theoretical foundation for making progress toward reducing the threat of climate change (but see Morgan, 2000; Victor et al., 2005). Two grounds exist, however, for doubting whether sole reliance on the conventional theory of collective action is the best scientific strategy. The first is the weakness of empirical support for the conventional theory of collective action related to small- to medium-size environmental

social dilemmas. The second is the existence of multiple benefits at small, medium, and large scales in addition to the reduction of GHGs at a global level that has been of primary concern in the academic and policy literature.

2.1. The lack of empirical support for the conventional theory of collective action

In a recent book, Poteete et al. (2010) review the empirical support for the theory of collective action related to environmental problems. They examine the evidence generated by in-depth case studies, meta-analyses of cases, large-scale comparative field studies, laboratory experiments, and agent-based models. While many instances of free riding are observed in the array of empirical research, a surprisingly large number of small- to medium-scale groups facing collective-action problems do cooperate (Agrawal, 2002; Baland and Platteau, 2000; Dietz et al., 2003; McKean, 2000; NRC, 2002; Ostrom et al., 1994; Schlager et al., 1994). Thus, before analyzing efforts to reduce the threat of massive costs related to climate change, it is essential to update the theory of collective action so that future policies are not made on the basis of a theory that appears to be obvious, but whose predictions regarding universal non-cooperation are not supported.

2.2. Updating the theory of collective action related to climate change

For future analyses of how individuals relate to natural resources at multiple scales, an updated theory of collective action needs to be based on a behavioral theory of human action and a recognition of the importance of context in affecting levels of trust and reciprocity of those involved. Further, the application of this theory to climate change also needs to examine whether smaller-scale externalities exist from the use of energy by individuals and firms that form a different foundation for future actions.

Since behavior in social dilemmas varies substantially across individuals as well as across settings, updated theoretical efforts depend on a behavioral theory of the individual (Camerer, 2003; Fehr and Gächter, 2002; Fehr and Leibbrandt, 2008) as well as on structural features of the particular dilemma that affect the likelihood of voluntary cooperation or relatively high levels of compliance with official rules. A behavioral theory of the individual assumes that individuals do not possess perfect information but are capable of learning as they interact in a particular setting. Individuals are boundedly rational and do seek benefits for self but vary in their other-regarding preferences and norms about the appropriate actions they should take in particular settings (Cox et al., 2007; Frohlich and Oppenheimer, 1992; Sen, 1977; Simon, 1955).

The capability of those involved to gain a reputation for being trustworthy and reciprocate others' efforts to cooperate with their own cooperation turns out to be a central characteristic of settings where moderate to high levels of cooperation are sustained (Milinski et al., 2002; Poteete et al., 2010; Rothstein, 2005). To achieve its objectives, any policy that tries to improve levels of collective action to overcome social dilemmas must enhance the level of trust by participants that others are complying with the policies, or many will seek ways of avoiding compliance. The crucial factor is that a combination of structural features leads many of those affected to trust one another and to be willing to take an agreed-upon action that adds to their own short-term costs because they do see a long-term benefit for themselves and others and they believe that most others are complying.

The problem of collective action does not disappear once a policy to deal with an externality is made by a government. Even government policies need to rely to a great extent on willing cooperation by citizens. When citizens approve of a government

policy and think they *should* comply, and this view is complemented by a sense that the government policy is effectively and fairly enforced, the costs of enforcement are much lower than when citizens want to evade the policy. Trust that government officials are objective, effective, and fair is more important in enabling a government policy to work than reliance on force (Rothstein, 1998, 2005).

3. Are only global benefits generated from reducing GHG emissions?

GHG emissions are the result of an extraordinarily large number of actions taken at multiple scales. Decisions within a family as to what forms of transportation to use, what car to purchase, and what investments to make regarding power consumption within their home affect not only the family budget but also the amount of GHGs released into the atmosphere. Similarly, decisions within business firms affect their budget as well as emissions.

Communities that have established power networks that enable households to invest in solar power to be used for household energy needs and, when not needed, contributed to a larger power network can reduce local energy costs and GHG emissions. Investments in better waste disposal facilities also generate local benefits as well as help decrease global emissions. Efforts to reduce pollution levels in large metropolitan areas focus on both total energy use and emissions of particulates and thus generate benefits at a metropolitan level as well as globally. Given that many of the actions generating GHG emissions are taken at multiple scales, activities that are organized at multiple scales generate benefits to those who act, ranging from households, farms, and cities at a local scale to regions within a state, states, regional units that cross state boundaries, and the globe (Kates and Wilbanks, 2003).

4. A polycentric approach

Over the last half-century, colleagues associated with the Workshop in Political Theory and Policy Analysis at Indiana University have developed the concept of polycentric systems for the analysis of collective-action problems involved in the provision of diverse public goods and services. Given that multiple benefits at diverse scales are generated from efforts taken to reduce GHG emissions as discussed above, polycentricity is a useful analytical approach for understanding and improving efforts to reduce the threat of climate change.

During the 1950s, massive criticism was leveled at the existing governance arrangements in metropolitan areas across the United States and Europe because of the large number of small-, medium-, and large-scale government units operating in the same metropolitan area. Many scholars thought that the high number of governments serving an area was evidence of a chaotic system (Friesema, 1966; Gulick, 1957). Ostrom et al. (1961) introduced the concept of polycentricity in their effort to understand whether the activities of a diverse array of public and private agencies engaged in providing public services in a metropolitan area were chaotic or potentially a productive arrangement:

"Polycentric" connotes many centers of decision making that are formally independent of each other.... To the extent that they take each other into account in competitive relationships, enter into various contractual and cooperative undertakings or have recourse to central mechanisms to resolve conflicts, the various political jurisdictions in a metropolitan area may function in a coherent manner with consistent and predictable patterns of interacting behavior. To the extent that this is so, they may be said to function as a "system". (1961, pp. 831–32)

Studies of water industry performance were carried out in California during the 1960s (Ostrom, 1962; Weschler, 1968). Substantial evidence was found that multiple public and private agencies had searched out productive ways of organizing water resources at multiple scales and simply the presence of multiple government units without a clear hierarchy was not chaotic.

Next, we studied the impact of governance arrangements in multiple cities for policing in a series of case comparisons of police departments serving similar neighborhoods within a metropolitan area. We never found a large department policing numerous neighborhoods that outperformed smaller departments within the same metropolitan area in regard to direct services to citizens. We found that while many police departments served the 80 metropolitan areas included in our next study, duplication of specific services by more than one department to the same set of citizens rarely occurred (Ostrom et al., 1978). We also found that the "most efficient producers supply more output for given inputs in high multiplicity metropolitan areas than do the efficient producers in metropolitan areas with fewer producers" (Ostrom and Parks, 1999, p. 287).

Polycentric systems are characterized by multiple governing authorities at differing scales rather than a monocentric unit (see Ostrom, 1999). Each unit within a polycentric system exercises considerable independence to make norms and rules within a specific domain (such as a family, a firm, a local government, a network of local governments, a state or province, a region, a national government, or an international regime). Participants in a polycentric system have the advantage of using local knowledge and learning from others who are also engaged in trial-and-error learning processes. As larger units get involved, problems associated with non-contributors, local tyrants, and inappropriate discrimination can be addressed and major investments made in new scientific information and innovations. No governance system is perfect, but polycentric systems have considerable advantages given their mechanisms for mutual monitoring, learning, and adaptation of better strategies over time.

Polycentric systems tend to enhance innovation, learning, adaptation, trustworthiness, levels of cooperation of participants, and the achievement of more effective, equitable, and sustainable outcomes at multiple scales, even though no institutional arrangement can totally eliminate opportunism with respect to the provision and production of collective goods (Toonen, 2010). Enabling citizens to form smaller-scale collective consumption units encourages face-to-face discussion and the achievement of common understanding. Creating larger collective consumption units reduces the strategic behavior of the wealthy trying to escape into tax havens where they could free ride on the contributions of others. Further, creating polycentric institutions related to climate change helps to fulfill the "matching principal" in international law that problems involving multiple levels (e.g., global, national, regional, and small scales) should involve contributions at each of these levels (Adler, 2005).

Some readers will ask, What is the relevance of the polycentric approach for the analysis of *global* public goods? The initial relevance of the polycentric approach is the parallel between the earlier theoretical presumption that *only* the largest scale was relevant for the provision and production of public goods for metropolitan areas, and the contemporary presumption by some scholars that *only* the global scale is relevant for policies related to global public goods. Extensive empirical research found, however, that while large-scale units were part of effective governance of metropolitan areas, small- and medium-scale units were also necessary components. An important lesson is that simply recommending a single governance unit to solve global collective-action problems—because of global impacts—needs to be seriously rethought.

As discussed above, instead of the benefits derived from reducing GHGs existing only at the global level, multiple benefits are created by diverse actions at multiple scales. Potential benefits are even generated at a household level. Better health is enhanced by members of a household who bike to work rather than drive. Family expenditures allocated to heating and electricity may be reduced when investments have been made in better construction of a building, reconstruction of existing buildings, installation of solar panels, and many other investments that families as well as private firms can make that pay off in the long run. As more information is provided about these small-scale, but cumulatively additive, benefits, one can expect further efforts to be undertaken that cumulatively and significantly reduce GHG emissions.

5. What efforts to reduce GHG emissions are actually being taken at less than a global scale?

If the polycentric approach is relevant for reducing the threat of disastrous climate change, it is necessary to ask what efforts to reduce GHGs are already being made at multiple scales. It is not possible to do a full inventory in this article of all ongoing projects across the world at multiple scales. What I can do is focus on some of the projects that have been organized by local and state governments in the United States, and discuss some of the European efforts to reduce emissions substantially.

5.1. Local-level efforts and alliances to reduce local-level externalities

Local-level efforts to reduce GHG emissions involve decisions regarding buying fuel-efficient cars, using other means of transport, using solar and wind power facilities, and insulating buildings within urban areas. "Buildings use 40% of the primary energy supplied in the United States, and more than 70% of all generated electricity, primarily for heating, cooling, and lighting" (Gershenfeld et al., 2010, p. 1086). Dietz et al. (2009) have identified 17 actions that can be taken within a home or a business facility that can cumulatively have a major impact on carbon emissions (see also Fuller et al., 2009; Gardner and Stern, 2008; Laitner et al., 2009; Vandenberg and Steinemann, 2007). Retrofitting buildings to add insulation, solar photovoltaics, and more efficient heating systems is an important strategy that can be taken at a local level and will actually generate a long-term savings to the family or firm that takes such actions in energy costs as well as reducing GHG emissions.

Methods for developing reliable city-scale GHG inventories have been developed and tested (Hillman and Ramaswami, 2010; Ramaswami et al., 2008). They are being used by many of the large number of cities across multiple countries that have pledged to reduce GHG emissions consistent with the Kyoto Protocol. In the United States alone, the mayors of 1026 cities have now joined the U.S. Conference of Mayors' Climate Protection Agreement to reduce GHG emissions by at least 5% relative to 1990 levels (U.S. Mayors' Climate Protection Agreement, 2010).

Cities and electric utilities have started to initiate a variety of "green" efforts. Some local utilities in the United States are now actively finding ways of reducing energy consumption by developing local monitoring systems that are then reported on the bills that customers receive (Kaufman, 2009). Using various forms of competition among households and groups, and feedback on who is doing the best at reducing energy use, is a strategy for reducing emissions that is being adopted by college campuses. Oberlin College, for example, tried out several methods of motivating dorm residents. In a rigorous evaluation of this effort, Petersen et al. (2007, p. 16) found that "the introduction of feedback, education and incentives resulted in a 32 percent reduction in electricity use."

Mayors of large U.S. cities are also banding together to discuss actions to reduce carbon emissions that can be taken locally, and if taken jointly can have a much bigger effect. In October 2005, 18 large cities sent representatives to London to examine actions that could be taken at a municipal level; to reexamine various urban policies that could be revised, including their own purchasing policies; and to discuss ways of encouraging more investment in climate-friendly technologies in their cities. The mayors viewed the results of the £8 congestion charge imposed by London on vehicles that drive within the city's central zone during business hours, from 7 a.m. to 6 p.m.¹

In October 2008, a merger of this network of large U.S. cities with the Clinton Climate Initiative was arranged to create the C40 Cities Climate Leadership group, whose members from Africa, Asia, Europe, Latin America as well as the U.S. have jointly pledged to reduce emissions in each of their cities to meet or even improve on Kyoto standards. In addition to the London meeting in 2005, C40 Large Cities Climate Summits have been held in New York City in 2007 and in Seoul in 2009. In June 2010, the Mayor of Berlin hosted a C40 Workshop on "Strategies for Highly Efficient Cities." These meetings enable extensive exchange of information about multiple policies adopted to reduce emissions. The Clinton Climate Initiative has also allocated \$5 billion to the global Energy Efficiency Building Retrofit Program, which is generating help to individual cities as well as technical information available to all members as well as anyone who searches the Internet.² Thus, many city governments and community organizations have recognized that actions at a local level are a major source of carbon emissions and that a need exists to tackle these locally.

5.2. State-level projects in the United States

California was one of the first U.S. states to pass major legislation—the "Global Warming Solutions Act" in 2006. The act requires drastic reductions from major industries including oil and gas refineries and utility plants.³ The Colorado legislature passed State House Bill 08-1350, signed into law in 2008, to enable local municipalities in Colorado to finance approved building improvements and property owners to pay off capital investments made to decrease their use of fossil fuels for heating and electricity through repayments over 20 years. In July 2007, Florida Governor Charlie Crist brought together government, business, and scientific leaders from across the state to discuss what actions could be taken by Florida to address climate change issues. At the conclusion of the meeting, several executive orders were signed to set out targets for reducing GHG emissions and to change the building code to require increased energy efficiency in new construction.⁴

Efforts are also being made among some of the eastern U.S. states to develop carbon markets (Rabe, 2004, 2007). The Regional Greenhouse Gas Initiative (RGGI), joined by 10 states in the Northeast and Mid-Atlantic, plans to reduce CO₂ emissions from the power sector by 10% by 2018.⁵ Furthermore, RGGI is one of the first cap and trade, market-based efforts in the United States aimed at reducing GHG emissions by auctioning emission allowances and investing the proceeds in various forms of clean

¹ A Wikipedia article on the "London congestion charge," an extensive compilation of information from London's transportation division and many news broadcasts and articles (http://en.wikipedia.org/wiki/London_congestion_charge; accessed May 4, 2010), reports that between 2003 and 2006, the CO₂ level in the city fell by 20% as a result of reduced traffic levels, better traffic flow, and improved vehicle technology. The speed of traffic flow and the reliability of bus schedules have also been improved.

² <http://www.c40cities.org/> (accessed July 5, 2010).

³ Global Warming Solutions Act of 2006, California Assembly Bill 32.

⁴ <http://www.dep.state.fl.us/climatechange/> (accessed May 4, 2010).

⁵ <http://www.rggi.org> (accessed July 4, 2010).

energy technologies and the creation of green jobs in each state. The eighth auction occurred on June 9, 2010. This experiment has generated substantial information about the efficiency of such auctioning strategies as well as leading to a reduction of GHGs in all 10 states.

5.3. European efforts

In Europe, various innovative interventions tend to combine local, national, and European levels (see Bulkeley and Kern, 2006). Mitrak (2009) provides an excellent overview of the multiplicity of national, regional, and local actors involved in planning activities related to reduction of GHG emissions in England. This collaborative planning provided essential background for the development of a new polycentric system—the Westmill Co-Op wind farm—which was successfully established after the involvement of many local, regional, and national actors in both the private and public sectors. Mitrak's study provides an excellent example of a polycentric system that led to enhanced power generation without contributing further GHGs.

At a regional level, the European Union Emissions Trading Scheme (EU-ETS) was developed to reduce the economic costs of meeting the EU's Kyoto target of 8% CO₂ reduction by 2012. Around 12,000 large industrial plants in the power generation, iron and steel, glass, brick, and pottery industries in Europe are included, but not the transport sector. Operators of these facilities receive emission allowances that are good for a 1-year period. If after verification an allowance is not fully used by the assigned operator, the unused portion may be sold to other facilities that have not met their assigned target.

5.4. Can actions taken by multiple units cumulate to reduce the threat of climate change?

While the actions to reduce GHG emissions already taken have not yet generated a major reduction of emissions across the entire globe, the result of these efforts is slowly cumulating. Furthermore, most of the units involved are major actors related to GHG emissions and can be expected to increase their contributions over time. The performance of the EU Emissions Trading Scheme, for example, has led to substantial reduction of emissions within the EU. The official data issued by the European Environmental Agency (EEA) in 2006 show that the EU members who had signed the Kyoto Agreement were able to achieve a 2% cut in CO₂ emissions in 2005 compared to 1990 levels. GHG emissions were projected to decline further by 2010 compared with 2004 levels (EEA, 2006, Sections 8 and 9).

In addition to the EU Emissions Trading Scheme and the RGGI scheme described earlier, three additional trading schemes have been established. A further development of the Clean Development Mechanism (CDM) of the Kyoto Treaty operates in the United Kingdom and involves a large number of firms. The World Bank has also created the Prototype Carbon Fund, which is similar in form to the CDM and invests in carbon-reducing projects primarily in developing countries. The Chicago Climate Exchange (CCX) program has been established for firms to trade credits based on their own voluntary emission cuts (Victor et al., 2005).

The State of California is not only the twelfth-largest emitter of GHGs in the world, but it is now one of the leading governments to adopt policies related to climate change (Engel, 2006). The California "Global Warming Solutions Act" of 2006 is aiming for a 25% reduction in GHG emissions by 2020 through requiring drastic reductions from major industries, including oil and gas refineries and utility plants.⁶ The California Air Resources Board is charged with developing a market-based cap and trade program to

implement the policy (Goulder, 2007). This program is essentially a local version of the CDM advocated in the Kyoto Protocol.

That the mayors of over 1000 U.S. cities have pledged to reduce GHG emissions by at least 5% relative to 1990 levels, as discussed above, is also an indication that local efforts are cumulating. It is not just a few local and regional bodies that are taking aggressive steps toward a reduction of GHGs. The attention given in the press to some of the initial steps taken by individual cities and states in the USA, and the effort of the EU to reduce emissions, has led many others, including not-for-profit organizations, to search out ways of reducing emissions while also gaining some localized benefits from these efforts.

In addition to the actual reductions of emissions that have been achieved recently, considerable experience has been gained with the use of diverse mechanisms. All of the voluntary efforts involve organizations that would in any case be involved in the actions needed to fulfill a global treaty requiring specific cutbacks of global emission. While the treaty would be signed by national governments, each country would need to develop internal policies involving its own government units, industry, and citizens to take actions that cumulatively generate the reductions agreed upon.

6. Does the number of actors working on climate change generate perverse outcomes?

One of the criticisms leveled at current efforts to reduce GHG emissions is that too many projects and activities are operating at multiple scales without effective support of a global treaty (Betsill, 2001). It is important that we examine some of the key problems that have been identified as plaguing efforts to control GHG emissions. Recognition of problems is essential to start serious efforts toward finding methods to reduce them. The problems raised most frequently are leakage, inconsistent policies, inadequate certification, gaming the system, and free riding.

6.1. Leakage

One of the problems frequently identified with subnational projects aimed at reducing carbon emissions is leakage. Two types of leakage can occur from policies adopted at less than global scale: leakage between locations and market leakage (Ebeling, 2008, pp. 49–51). Leakage between locations occurs when an activity that would have occurred in X location is shifted to Y location because of a climate change project that occurs in X location. The EU-ETS and RGGI efforts to reduce emissions from industrial producers may, in some cases, simply shift the emissions that would have been produced in Europe or the United States to a developing country that has less stringent policies on GHG emissions or none at all. For example, the EU-ETS program may be responsible for shifting production to countries that allow a free-for-all where the costs of production may be lower, but carbon is still emitted in the production of chemicals and in the transportation of the chemicals to European locations (Chomitz, 2002; Sovacool and Brown, 2009). Similarly, farmers who are forced to leave a location due to a tree-planting project may simply move to a new location and cut down the timber located there unless they must make commitments that will be carefully monitored.

Market leakage refers to the changes in the price structure that may occur as a result of restrictions placed on harvesting from forests. Such restrictions reduce the volume of timber and other forest products generated in one area. This stimulates an increase in the prices of these products. If everything goes well, higher prices encourage the intensification of agricultural and forest production in other areas, and they do not stimulate more deforestation. "In a less favorable scenario, particularly when land-use regulations are poorly enforced, higher prices provide an

⁶ Global Warming Solutions Act of 2006, Calif. Assembly Bill 32.

additional incentive to clear forests for timber or agriculture elsewhere, thereby reducing the net benefits of the climate mitigation project" (Ebeling, 2008, p. 50).

6.2. Inconsistent policies

Closely related to the problem of leakage is the problem of inconsistent policies. Industrial firms that are trying to develop new technologies to reduce GHGs may find it costly when policies vary in different regions. Potential sales of new technology are limited to those areas where the technology fits the policies adopted, and these areas may not be large enough to generate substantial sales warranting the investment in new technology.

6.3. Inadequate certification

For policies adopted at any scale that provide diverse rewards for projects that reduce GHG emissions, there is a need for skilled personnel to certify that the project does indeed reduce ambient CO₂ by some specified amount over a defined time period. A very active new industry of "global consultants" has emerged. While many consultants do have good scientific training, the greatly increased need for certification has generated opportunities for some unqualified contractors to earn money in the new "certification game." Sovacool and Brown (2009, p. 14) report on one study that evaluated 93 randomly chosen CDM projects and "found that in a majority of cases the consultants hired to validate CERs [Certified Emission Reports] did not possess the requisite knowledge needed to approve projects, were overworked, did not follow instructions, and spent only a few hours evaluating each case."

6.4. Gaming the system

It is also feasible for some actors to adopt strategies that take advantage of current carbon credit trading systems, including the CDM, that include credits for "reducing" emissions of six Kyoto Protocol gases. Wara (2007) examined the distribution of CDM projects and noted that only one-third of emission reductions involve lowering CO₂ or reducing energy production. Instead, "the largest volume of credits, almost 30% of the entire market, come from capturing and destroying trifluoromethane (HFC-23)" (Wara, 2007, 595), which is a by-product of manufacturing refrigerant gases. The emitters of this gas "can earn almost twice as much from CDM credits as they can from selling refrigerant gases" (Wara, 2007, 596). Thus, some firms appear to have started to manufacture HFC-23 primarily to obtain credits in a carbon market without significantly reducing a gas that produces CO₂.

6.5. Free riding

Whenever actions taken by some individuals or organizations benefit a larger group, a risk always exists that some participants will free ride on the efforts of others and not contribute at all or not contribute an appropriate share. At the current time, there are many government and private entities at multiple scales that are increasing their GHG emissions substantially—especially in the developing world—without adopting any policies to reduce their emissions in the future. This is a major problem. And current debates over who caused the great increase in the presence of GHGs in the atmosphere in the first place and thus who should be paying the most in the future are legitimate debates.

7. Concluding thoughts

The intent of this article has been to explain that a polycentric system for coping with global climate change is emerging and is

likely to expand in the future. This development is not consistent with the conventional theory of collective action that predicts that actions taken to reduce a joint risk are unlikely to occur without an externally enforced set of rules. As a result, many analysts have presumed that an enforceable global agreement is the only way to address the threat of climate change. There is no question that an international treaty is a major step that needs to be taken as soon as international leaders can agree on a variety of pressing issues related to responsibility for past and future emissions and the most effective future rules. But instead of focusing entirely on this vital, but missing step, it is important to recognize the evolving polycentric system both for its strengths and weaknesses.

Regarding the conventional theory of collective action, empirical research has documented multiple settings where participants have made tough efforts to achieve a variety of collective benefits. Repeated findings of studies of commons around the world successfully challenge the conventional theory prediction that those directly affected are helpless and cannot themselves take actions that address a problem of collective action. What we have learned from extensive research is that when individuals are well informed about the problem they face and about who else is involved, and can build settings where trust and reciprocity can emerge, grow, and be sustained over time, costly and positive actions are frequently taken without waiting for an external authority to impose rules, monitor compliance, and assess penalties.

While the global commons is dramatically larger than the many local commons that have been studied, discussions within the family and with neighbors in a community about actions that can be taken locally to reduce GHG emissions are important factors leading to the potential for positive change. Local discussions and meetings generate information about the unrecognized costs of individual, family, and business activities as well as potentially lead to a change in the preferences of individuals involved and about the expected behavior of others. As a result of this communication, some actors adopt a sense of ethical responsibility for their own carbon footprint. Through these discussions and reading about efforts by multiple actors to reduce GHGs, individuals may recognize that they can achieve benefits as a result of taking costly actions that combine with the actions of others to reduce the threat faced by all. Even without major taxes imposed on energy at a national level, families that decide to invest in better insulation and more efficient furnaces and other appliances, to join a carpool whenever feasible, and to take other energy-conserving actions do save the family budget over the long run. They may face high up-front investments to achieve some of these benefits, but there are potential benefits to be achieved at a household level. Similarly, the discussions held among mayors and other political leaders at local, state, and regional levels enhance their knowledge of policies they can adopt and how linking with others increases the benefits and impact of their actions.

Self-organized, polycentric systems are not a panacea! There are no panaceas, however, for complex problems such as global warming. Besides the general benefits that a polycentric system can generate, there are also threats as briefly discussed above. Some of these threats would also exist in any worldwide system developed as a result of a global treaty. As expected, free riding is an important threat to a system that evolves without the presence of an enforceable treaty. One should also expect, however, that actors who are not convinced of the importance of reducing carbon emissions would attempt to free ride even if a global treaty were successfully negotiated.

Given the complexity and changing nature of the problems involved in coping with climate change, "optimal" solutions for making substantial reductions in the level of GHGs emitted into the atmosphere are only a dream. A major reduction in emissions is, however, needed. The advantage of a polycentric approach is that it

encourages experimentation by multiple actors, as well as the development of methods for assessing the benefits and costs of particular strategies adopted in one setting and comparing these with results obtained in other settings. A strong commitment to finding ways of reducing individual emissions is an important element for coping with climate change. Building such a commitment, and trusting that others are also taking responsibility, can be more effectively undertaken in small- to medium-scale units that are linked together through diverse information networks.

We need to recognize that doing nothing until a global treaty is negotiated maximizes the risk involved for everyone. Rather than only a global effort, it would be better to self-consciously adopt a polycentric approach to the problem of climate change in order to gain benefits at multiple scales as well as to encourage experimentation and learning from diverse policies adopted at multiple scales.

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